The Nature of Monte Carlo Mine Burial Prediction

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The Nature of the Problem

- Mine burial is stochastic
  - Large number of physical influences, some of which are stochastic
  - Initial conditions at deployment uncertain (small changes initially may result in very large differences in the end state).

- Best possible prediction: probabilities for different states of burial.

Monte Carlo Approach

Use deterministic models of impact and subsequent burial in a Monte Carlo simulation to calculate burial of a large number of mines.

- Random numbers generator - > probability density for each initial variable.
- Direct computation of burial over the life of each mine.
- End result: final states of a large number of mines.

Monte Carlo Approach (cont.)

- Results are used to determine probability for different states of burial in a particular region of interest over time.

- Probabilities are associated with lat/long positions to form maps of mine burial probabilities in operational area.

- An analyst can then use these maps to plan mine clearance or avoidance (go/no go).

Monte Carlo – High Level View

Mission planning

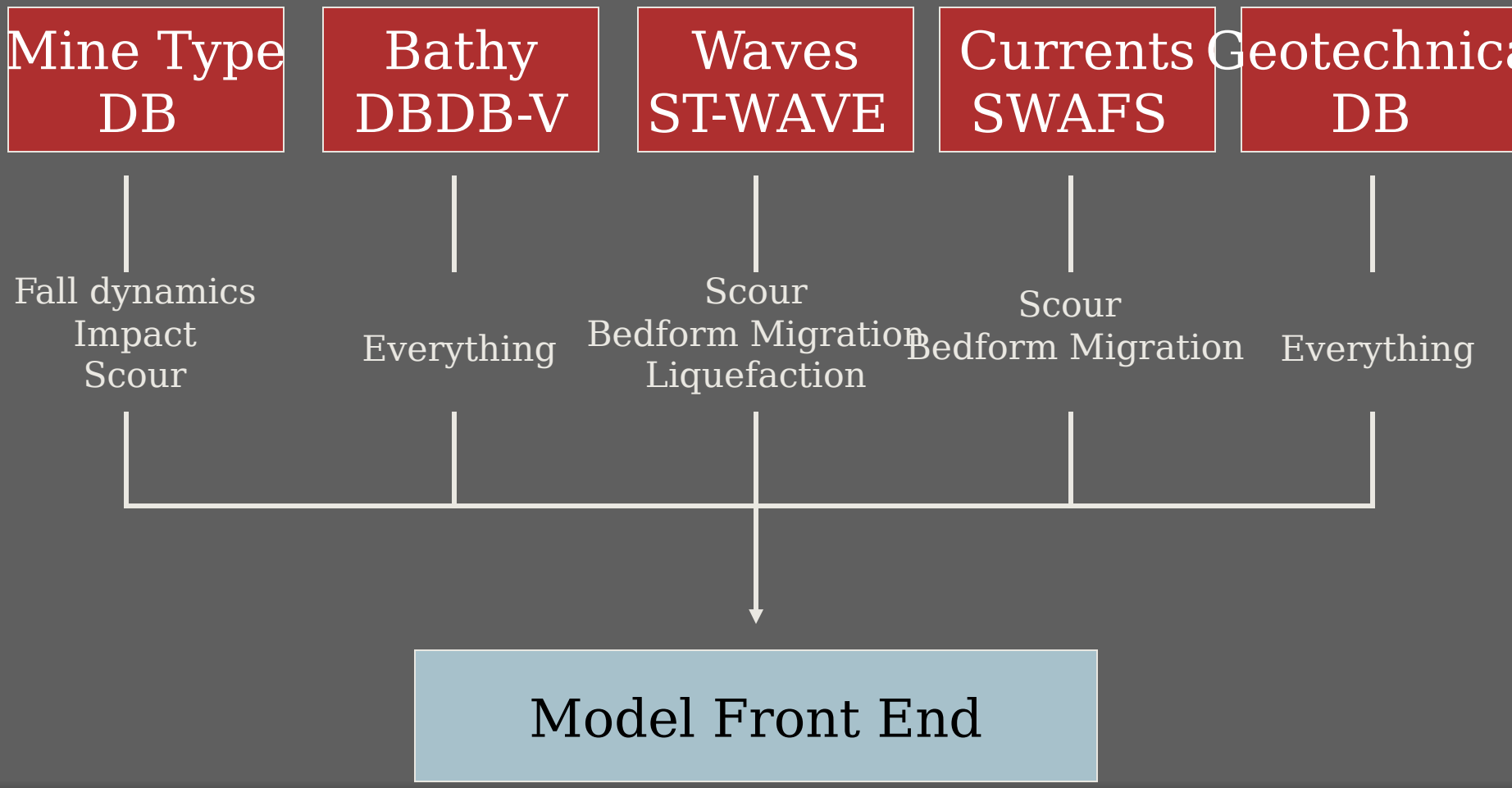
→ NAVO DB and model results

→ Front end of MC model

→ MC Run(s)

→ End result and analysis

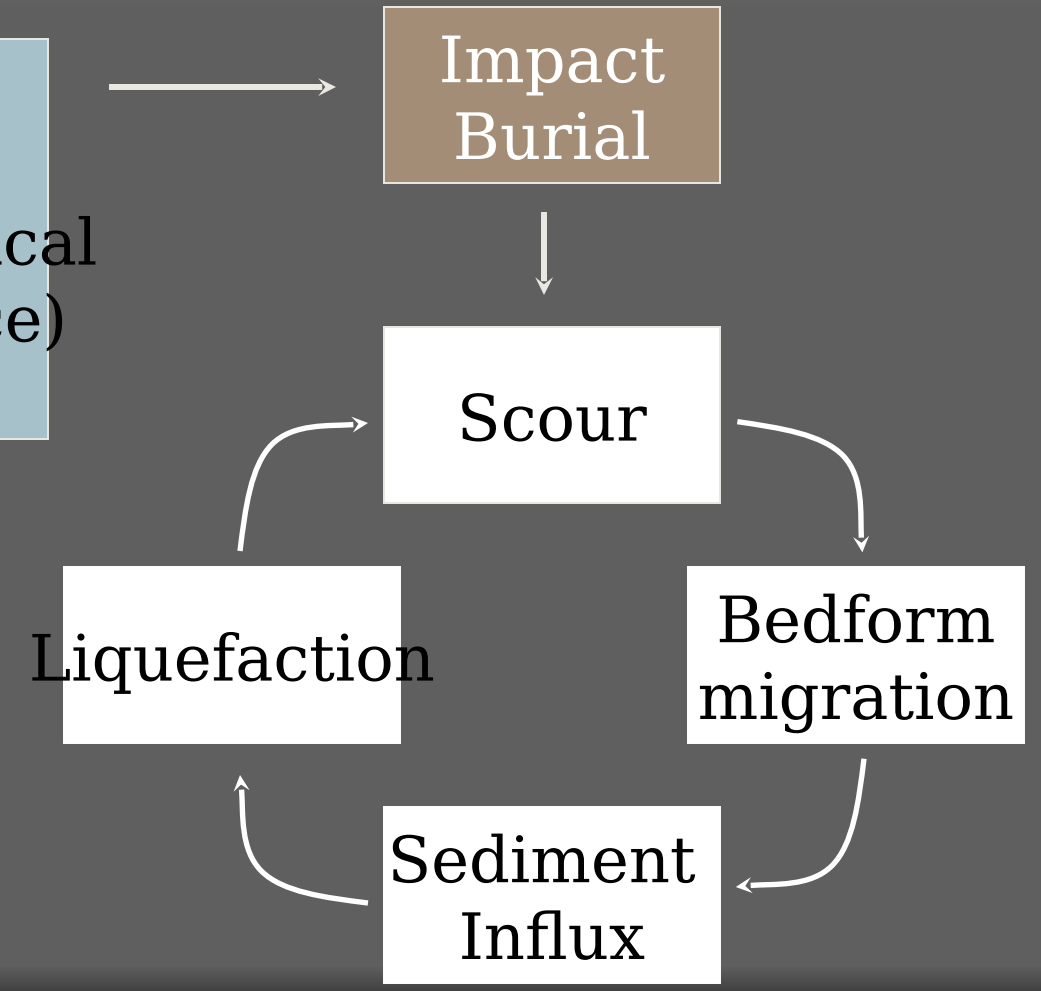
NAVO Model and DB Input



Model Mechanics

(one run)

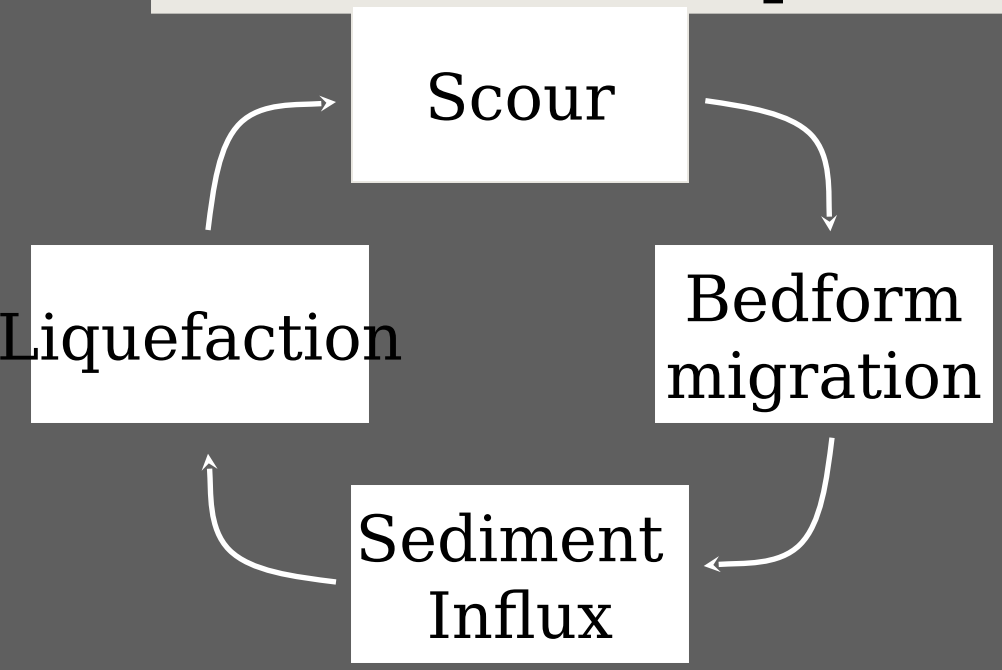
Model Front End
- DB and model ingest
- PDF's (models, historical data, intelligence)
- Monte Carlo



Model Mechanics

(Subsequent Burial Process)

Turn-based coupling of post-impact processes.



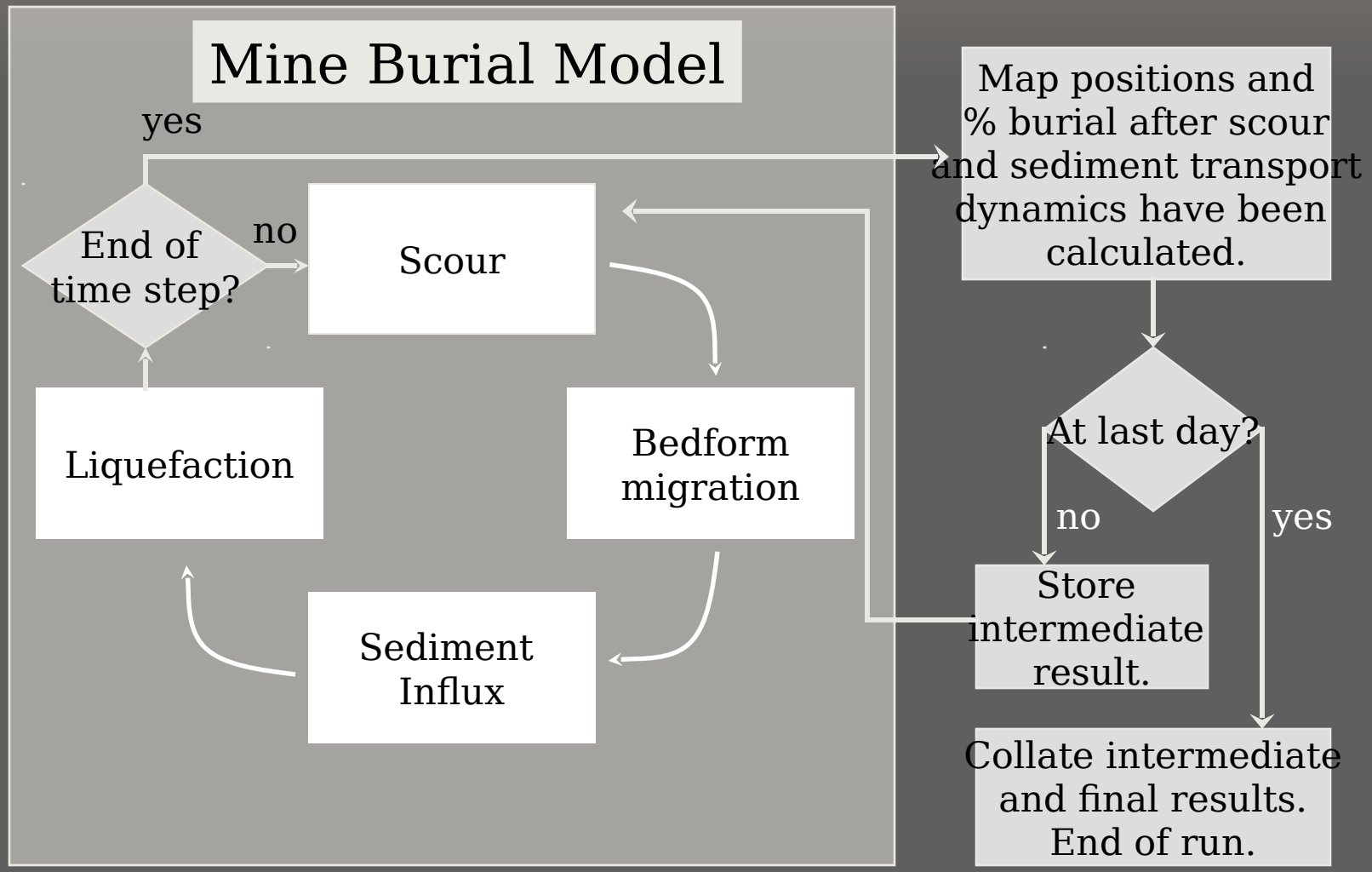
Processes “take turns”- operate one at a time cyclically.

Period of the cyclic made small relative to mine life so that a continuous coupled process is approximated.

Analogy: Card game. Each player is idle at the table until it is their turn to play a card.

Model Mechanics

(Saving Intermediate and Final Results)



Some Currently Available Components

Impact Burial: Batch 28
- IMPACT 28 with Monte Carlo shell
- Coded in QBASIC and MATLAB

Scour: HR Wallingford Equations
- Validation and “tweaking” against NRL mine data
- Coded in MATLAB

Sand Ridge Migration: Mulhearn model
- Australian defense research
- Currently in a technical report, needs coding

Leveraging MBP Modeling Efforts

Process models (Impact and Post-Impact)	→	Holistic models (Expert System, Monte Carlo Sim)
• Form the parts required by holistic models.		• Use process models as parts in an overall model
• Q/A of physics and define applicability		• Integration, statistics, and end product

r factory analogy: Process models form the car parts (brake
nsmission, etc.). Holistic models are the assembled car.

The Nature of the Prediction

- Stochastic problem -> probabilistic prediction.
  - Probabilities for different states of burial
  - Time dependent
  - Risk analysis and planning required afterwards

- Uncertainties
  - Convergence of a solution
  - Sensitivity of variables to change
  - Accuracy of the impact and subsequent burial models
  - Capabilities/Limitations of databases

End Goal – Avoid This!